Broadband Wireless Access for the First Mile

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Abstract
Residential Internet users, as well as small and medium-sized businesses, require higher-bandwidth network access than most can obtain. Because such users will increasingly originate as well as consume data, the access link will be their "first mile" as well as their last. Broadband *wireless* access (BWA) is a potentially economical and easily deployed competitor for high-speed access. However, BWA will not significantly penetrate the low end of the market until the cost of customer-premises equipment falls dramatically. With the coordination of NIST's National Wireless Electronic Systems Testbed, the industry is beginning to recognize that interoperability standards, currently absent in the field, are critical to success, and to address standardization through a new working group.

Broadband Access
The need for broadband access in the residential and small-to-medium-sized business environment is well known. In the past few weeks and months, press coverage of the race to provide ubiquitous broadband access has itself become ubiquitous.

Full Two-Way Access
Broadband access is often called the "last mile" problem. This term unconsciously expresses a prejudice against residential and small business users, suggesting that such users are primarily consumers of data. I argue that we need to address this issue closely. Development of the Internet and the business conducted over it have been difficult to predict. It is possible that small users will become less interested in passive multichannel video and increasingly demanding of "upstream" bandwidth for data they originate. Video telephony is one obvious source of such data. I won't speculate as to others, but I think that even residential users will be increasingly interested in originating and distributing data. For these users, the broadband access link will be the "first mile" in the network.

Wired Broadband Access

Most of the press focuses on cable modems and digital subscriber lines (DSL). Both have obvious potential. However, both are expensive. The popular press suggests that the existing cable and telephone infrastructure gives the owners of that plant a readily available “data pipe” to exploit, with only the proper modems required at the periphery. This is a misleading picture. The cost of rebuilding the cable infrastructure as a two-way hybrid fiber coaxial (HFC) system is enormous; the primary assets held by the cable operators are their municipal rights to operate and their rights-of-way to string optical fiber lines along utility poles. The only real physical assets are not the last mile to the residence but only the last 30 meters of coaxial cable from a utility pole to the residential living room; the rest of the plant needs to be rebuilt, at great expense. In some cases, DSL can be deployed without major infrastructure changes. However, the number of potential users within DSL’s distance limitations is a fraction of the market. Furthermore, *Red Herring* (May 1999), citing a research firm, reports that each ADSL (Asymmetic DSL) line costs over $2000 to install and that ADSL Lite is closer to $1200 (“not including the cost of training service, support, and sales personnel”).

Regarding access areas, DSL has very limited range relative to the central office. HFC cable systems have virtually no range limitation due to the fiber infrastructure. Cable networks are a strong presence in residential areas, but very little cable exists in commercial districts.

Regarding the technology, I am personally concerned about the inherent bandwidth limitations of cable modems. Cable is a shared medium. My impression is that the first few cable modem users in a neighborhood are delighted by the service but begin to regret that they expressed this delight to their neighbors as they find themselves sharing their bandwidth. Cable companies will reply that they can always split nodes to provide more capacity. However, this is expensive and could provide relatively small increases in bandwidth per user (for instance, a factor of 10 increase would be difficult). I am particularly concerned with the very narrow allocation of bandwidth on the “upstream” side. The cable companies seemed to have designed their technology to serve a nearly passive consumer of data and video. The technology appears to lock out any significant increase in the upstream/downstream bandwidth symmetry.

Broadband Wireless Access

Broadband wireless access, while not well established as an alternative broadband access system, is potentially a significant competitor. These systems typically use licensed microwave or millimeter wave frequencies to connect network nodes to fixed users sites through a rooftop antenna. Some possibilities are:

• Point-to-point systems, which connect a single user terminal. These are common, particularly in the 38 GHz band. They are designed for a single, high-bandwidth user, not for the masses.

• Point-to-multipoint terrestrial systems, which are cellular structures in which a single base station serves a neighborhood. Industry is moving toward such systems, with bandwidth-on-demand capabilities, due to their spectral efficiency. However, the technology is still being developed, there are no interoperability standards, and the cost of the user terminal is prohibitive for small customers.

• Space-based platforms, using various orbital levels and service provisions. There are many proposed competitors. The cost is very high, and low earth orbit systems are not operational until virtually all of the satellites are. The systems will provide very broad earth coverage, even to rural and remote areas. For that reason, some are likely to be successful. However, since their bandwidth (typically about 1 GHz) is shared by users across huge areas of the earth's surface, I am concerned about their ability to provide bandwidth to a large number of users. I imagine that spot beams might provide sufficient frequency reuse, but I am not familiar with the practicalities or cost effectiveness nor with the specific plans of the companies in this regard.

• Stratospheric platforms, in which the base station is mounted high in the atmosphere. The two major existing proposals plan unmanned dirigibles and manned airplanes. Both seem to provide feasible solutions for metropolitan regions. As in the space-based case, frequency reuse is a concern. The piloted airplane has the attractive feature, particularly compared to satellites, that the base station returns the ground every eight hours; this provides an opportunity for maintenance. Satellites, on the other hand, need to last for many years, and the cost of failure is dramatic, so the systems must be extremely reliable and therefore very costly.

Fixed Terrestrial Broadband Wireless Access

Fixed terrestrial broadband wireless access is currently deployed in much of the world. The major U.S. operators work primarily at 24 and 38 GHz. Multichannel multipoint distribution service (MMDS) license holders, operating around 2 GHz, are expecting to soon receive approval from the U.S. Federal Communications Commission (FCC) to offer two-way services.

The interest in broadband wireless access grew dramatically when the FCC, in early 1998, auctioned the largest block of spectrum ever distributed for what they called Local Multipoint Distribution Services (LMDS); an auction of remaining LMDS licenses is planned for 1999. Unfortunately, many of the LMDS license holders are loath to invest in infrastructure until the equipment suppliers can agree on standards. Furthermore, the currently planned deployments aim at business markets, in which the cost of the customer premises equipment is relatively affordable. As noted in "Millimeter Wave 1998: Broadband Wireless and Automotive Radar Markets, Opportunities & Forecasts" (Allied Business Intelligence), "Subassembly and chip manufacturers simply cannot supply the performance that millimeter wave system manufacturers desire at a price which is feasible for significant penetration into the consumer market today... LMDS may be closest to achieving this goal, but its lack of a unified standard and lack of commitment to significant volumes will inhibit further price declines."

Wireless Standardization in the U.S.

Historically, standards for wireless systems were fully specified by regulation of the FCC. Beginning in 1994, the FCC began auctioning and granting deregulated licenses, leaving technology choices to the marketplace. However, market competition in the U.S. has not yet led to dominant standards that would lower the equipment costs, establish strong U.S. industrial competitiveness abroad, and open the marketplace to smaller corporate players. Meanwhile, none of the billions of dollars collected at auction have been applied by the government to promote efficient commercialization of the spectrum.

The National Wireless Electronic Systems Testbed (N-WEST)

The National Wireless Electronic Systems Testbed (http://nwest.nist.gov) is a collaboration of two U.S. Department of Commerce agencies, the National Institute of Standards and Technology and the National Telecommunications and Information Administration, to accelerate the commercialization of wireless spectrum through standardization. Standards committees often break down over unsubstantiated claims and counter-claims of technical superiority. A neutral laboratory testbed can supply the unbiased measurement results that will illuminate the technical discussion and establish industry consensus. N-WEST is developing a BWA testbed to provide the measurement data required to support the rapid consolidation of industry consensus standards. At the same time, N-WEST will correlate system performance to component characterization to ensure functionality without building in excess costs due to overspecification of components. N-WEST plans to also help study some of the technical barriers to BWA success, particularly regarding propagation. Line-of-sight limitations, foliage interference, and depolarization are key issues facing deployment in residential areas.

The N-WEST–Led Industry Standardization Process

In the spring of 1998, NIST, through N-WEST, began moving to build an industry consensus on the importance and feasibility of interoperability standards. N-WEST organized an effort of 69 Supporting Companies, including trade associations, service providers, systems integrators, and component manufacturers (see Appendix). This group of Supporting Companies has held four meetings involving 135 people from over 80 companies.

The Supporting Companies approached the influential IEEE 802 LAN/MAN Standards Committee of the Institute of Electrical and Electronics Engineers (IEEE) regarding this standards issue. A resulting 802 Study Group, which included 97 attending members from 70 companies, returned with a plan to standardize the BWA air interface. IEEE responded by chartering the IEEE 802.16 Working Group on Broadband Wireless Access in March 1999. The trade press, as well as the industry, has been optimistic about this effort; for example, *Network Computing* said about BWA on February 8, 1999, “Equipment vendors don’t have a full set of standards to guarantee interoperability. Without standard equipment, all components in each cell must come from the same vendor, exposing the carrier to a considerable risk. Fortunately, the

IEEE 802 Study Group on Wireless Access is expected to forward a plan for LMDS standardization by next month."

Appendix: 69 N-WEST Supporting Companies

- 3Com Corporation
- ADC Telecommunications
- AMP M/A-COM
- Alcatel Network Systems
- Andrew Corporation
- Anritsu Company
- Antilles Wireless Cable TV Co.
- Asvan Technology, LLC
- Bellcore
- Belstar Systems Corp.
- BroadBand Wireless Inc.
- C&W Systems, Ltd.
- Cable AML Inc.
- Cellular Telecom. Industry Assn. (CTIA)
- Charles Brinkman
- CircuitPath Network Systems
- E B Systems Limited
- EDX Engineering, Inc.
- EER Systems
- ETM Electromatic
- ETRI, Radio & Broadcasting Tech. Lab
- Ensemble Communications
- Ericsson Inc.
- Formus Communications, Inc.
- Fujitsu Compound Semiconductor, Inc.
- Gigabit Wireless Inc.
- Hardin & Associates, Inc.
- Harris Corp.
- Hewlett-Packard Co.
- HRL Laboratories
- IDT Inc.
- Illinois Institute of Technology
- Integrity Communications
- Intraplex
- ioWave, Inc.
- Istari Design, Inc.
- LCC International Inc.
- Lucent Technologies
- MLJ, Inc.
- Millitech Corporation
- Motorola Inc.
- NEC America, Inc.
- Netro Corporation
- Newbridge Networks Corporation
- Nortel Networks
- Phasecom, Inc
- P-COM
- Philips Broadband Networks
- Raychem Corp.
- Raytheon Systems Company
- Run.com Communications Ltd.
- Sanders, A Lockheed Martin Co.
- SiCOM, Inc.
- Siemens Microelectronics, Inc.
- Spike Technologies, Inc.
- Stanford Wireless Broadband Inc.
- Technical Strategy Associates
- TelesciCOM Ltd.
- US WEST Advanced Technologies
- WFI
- WNP Communications,Inc.
- WaveCom Electronics Inc.
- WaveSpan Corporation
- Wavtrace
- WinNet MCS
- WinStar Communications, Inc.
- Wireless Communications Association Int'l
- Wireless Valley Communications, Inc.
- Wytec Inc.